

DESIGN OF FIXED DOME DOMESTIC BIO DIGESTER FOR DEGRADATION OF KITCHEN WASTE USING MESOPHILIC & THERMOPHILIC REACTIONS (ANAEROBIC)

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ABSTRACT

Solid waste generation rates are rising fast with a pace of 11 million tons per day on a worldwide scenario. Therefore, there is a need to solve this problem by segregating and degrading the waste using various technological advancements. Biogas technology can alleviate several problems mainly energy crisis in rural areas, low agriculture yield and sanitation affairs. The main purpose of the study is to outline conditions under which biodigesters would be feasible to society and help to decipher the mentioned problems. It focuses on solving waste management at household level and production of biogas as an alternative source of energy. Wet organic waste from homes is crushed and mixed with water and fed to the fixed dome biodigester which will produce 0.4 cubic meter of gas per day. As the domestic biodigester operates in the absence of oxygen in sealed tanks, it reduces problems related to odors. The digester can be fitted with solar panels or electric heaters, depending upon the climatic conditions. The main agenda is designing and fabricating such a biodigester that is economical, compact and functions effectively.

Keywords: Domestic Waste Management, Kitchen Waste, Biogas, Fixed Dome, Biodigesters, Solar Heater.

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1. INTRODUCTION

Due to industrialization and increase in population the waste produced per day has risen tremendously. Thus, making it essential for us to identify an alternative method to dispose waste. Efforts are made to overcome pollution occurring due to incineration and landfill dumping. Since the environmental and health effects due to these hazardous activities could be extensive it is important to nip it at the bud itself. Various researches have been conducted to treat organic waste and improve biogas production.

Anaerobic digestion is one of the most widely used and effective way of treating solid organic waste. Anaerobic digestion means breakdown of organic matter under the action of microorganisms in the absence of oxygen. The byproduct after decomposition of the organic waste is methane, carbon-dioxide along with a nutrient-rich residue which acts as a bio-fertilizer. Anaerobic digestion can be operated in two stages, namely mesophilic reaction followed by thermophilic reaction (temperature typically maintained between 30-40°C and 40-55°C respectively). To obtain effective results the digestion process is carried out in large digestive tanks which are kept sealed and mixing is done thoroughly to maximize contact between bacteria and organic waste. Mixing is done either by mechanical stirrer, hydraulic or pneumatic methods or by recirculation of gas or slurry.

1.1 PROBLEM STATEMENT

Developing countries are still in the transition towards better waste management but they currently have insufficient collection and improper disposal of organic wastes. Services and programs that include proper waste disposal for management of hazardous biological and chemical wastes, minimization and recycling will be needed. Disposal of organic wastes is commonly done by dumping (on land or into water bodies), incineration or long term storage in a secured facility. All these methods have varying degrees of negative environmental impacts and adverse environmental and health risks is organic wastes are improperly disposed or stored. Thus we have designed the fixed dome domestic bio digester for degradation of kitchen waste using mesophilic & thermophilic reactions.

1.2 OBJECTIVES

1. To design and fabricate biodigester for wet waste management.
2. To initiate waste management at domestic level.
3. To use renewable solar energy, that helps to make the biodigester compact and economical.
4. To reduce waste and land pollution.
5. To make an odor free environment by the use of anaerobic process.

1.3 SCOPE

1. The methanisation process produces a bio-slurry (fertilizer) that has valuable fertilizing properties, predominantly playing a vital role in the agricultural sector.
2. Due to fixed dome domestic biodigesters, the sanitary conditions can be enhanced. Smoke and pollution caused by burning fossil fuels and firewood is also reduced thus reducing respiratory diseases.
3. Use of biotechnology is economic as well as it is non-polluting and we obtain renewable source of energy from organic waste which indirectly helps to reduce landfills, incineration and deforestation.
4. These anaerobic digesters are compact and they degrade the organic waste in the absence of air in sealed tanks thus, odorless and are easily adaptable at the household level. Moreover, we do not require highly skilled operators to operate these and maintenance cost is minimal.
5. Use of solar heater for heating of tanks provides conservation of energy.

2. LITERATURE REVIEW

2.1 Anaerobic digestion of kitchen waste to produce biogas;

“Salma A. Iqbal, Shahinur Rahaman, Mizanur Rahman, Abu Yousuf”

Kitchen waste (KW) can be utilized to produce biogas due to its high biodegradability, calorific value and nutritive value to microbes, which will reduce our dependency on fossil fuels. The research work was conducted to investigate the production ability of biogas as an alternative energy from KW with co-digestion of cow manure (CM) through anaerobic digestion (AD). Firstly, three digesters were prepared to observe the individual degradation rate of KW, CM and co-digested KW with CM at room temperature (25°C~30° C) and at temperature of 37°C (mesophilic digestion) respectively and observed the degradation rate for co-digested KW with CM was higher than KW and CM alone. Secondly, three digesters were constructed to observe the effect of alkalinity at temperature 37° C and loading rate 200 gm/L. Three alkali (NaOH) doses 1.0%, 1.5% and 2.0% on wet matter basis of kitchen waste were applied to improve biodegradability and biogas production. The highest degradation rate was 6.8 ml/gm which was obtained from 1.5% NaOH and also observed that biogas production was almost doubled from treated KW than untreated KW. The prime object of this work was to investigate the prospect of kitchen waste for biogas production and ultimate protection of environment from the bad effect of methane gas that would be produced by uncontrolled anaerobic digestion.

2.2 Design of Bio Gas Generation Plant Based on Food Waste;

“Rajendra Beedu and Pratik Modi”

This paper deals with the design and fabrication of a food waste based biogas generation system. An experimental setup is designed and implemented and the paper illustrates the working principle, chemical analysis, cost effectiveness of biogas plant compared to Liquid Petroleum Gas. Also the paper explains the method of transportation of waste food from different locations to multiple biogas plants.

2.3 Potential of Using Kitchen Waste in a Biogas Plant

“A. Apte, V. Cheernam, M. Kamat, S. Kamat, P. Kashikar, and H. Jeswani”

India's economic growth is contributing to a massive increase in the generation of solid waste. Approximately 55 million tons of Municipal Solid Waste is generated

annually by urban areas in India. However, due to our country's dwindling petroleum reserves and increased costly imports of petroleum, non-conventional energy resources are slowly gaining importance. The use of biogas using kitchen waste as feedstock can help solve the problem of energy deficit and at the same time, allow the safe disposal of kitchen waste which is often unscientifically dumped or discarded. Our institute campus (Bhavans' campus) has a number of campus kitchens that utilize several LPG cylinders and also generate large amounts of kitchen waste. The biogas produced can be used to supplement the fuel requirements of the campus kitchens that generate the kitchen waste. This study consists of carrying out survey, characterization of kitchen waste from several kitchens and exploring its potential to be used for biogas production.

2.4 ARTI

The Appropriate Rural technology institute uses the floating drum type digester of 1m^3 capacity of which the gas holder capacity is 0.75m^3 . The kitchen waste of 4-5 families is collected, out of which half of the waste is cooked food (roti soaked in water and smashed cooked potatoes) and the other half is uncooked food (spoiled fruits and vegetable waste). To begin with the waste input procedure they add 1kg of waste, next day followed by 2kg and hence keep increasing the daily input up to needed. The retention period of their digester is about 24-72 hours. On the first day about 60% of methane and 40% of other gases (carbon dioxide, hydrogen sulphide) is obtained. As the bacterial reaction is best suited at 35°C the bio digester should be placed in the vicinity of sunlight.

3. METHODOLOGY

3.1 WORKING

We are designing bio digester which is having a fixed dome, to utilize the kitchen waste by degrading it and the output will be production of methane of methane gas in small quantity and digestate as a fertilizer. The construction of the digester includes two tanks, one for mesophilic anaerobic reaction followed by thermophilic anaerobic reaction. The chemical reactions involved are hydrolysis, acidogenesis, acetogenesis and methanogenesis. The digester is compact and potable.

An amalgam of finely ground kitchen waste and water is made in 1:1 proportion. For 1 liter of solid organic kitchen waste, 1 liter of water is used as feed to the mesophilic tank. Adding sufficient amount of water to the organic matter is essential as it creates a suitable environment for easy degradation and provides the substrate with fluid properties. A constant temperature of 35°C is maintained using a solar heater. Production of biogas due to bacterial action will occur within 30-40 days with the complete decomposition of the substrate. Furthermore, to improve degradation and improve gas production regular stirring is done. The gas gets collected in the dome while the substrate commences to move towards the balancing tank due to the pressure difference. The substrate is directed through the outlet pipe towards the second tank where it undergoes thermophilic reaction. With the help of biogas produced in the mesophilic tank, it attains the constant thermophilic temperature at 55°C . Thus, remaining gas production takes place which is drawn through the gas valve. Slurry is then taken out from the draining pipe from the bottom of the tank.

3.2 DIAGRAM

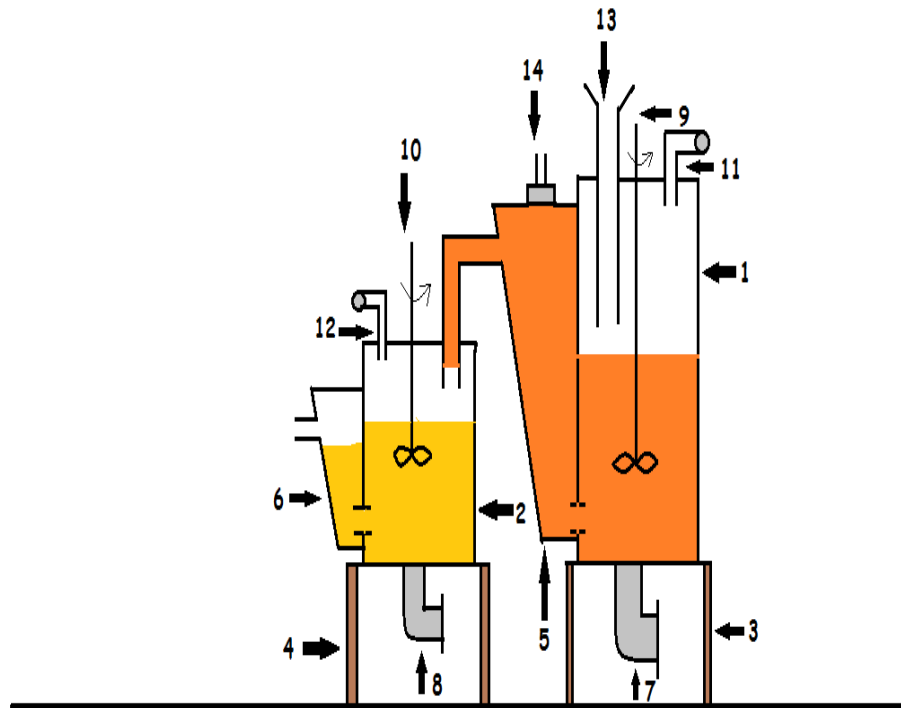


Figure1. Fixed Dome Domestic Biodigester

LABELLING

1. Mesophilic tank
2. Thermophilic tank
3. 3 & 4- Stands
4. 5 & 6- Balancing tanks
5. 7 & 8- Slurry outlet pipes
6. 9 & 10- Stirrers
7. 11 & 12- Gas outlet pipes
8. 13- Feed inlet pipe
9. 14- Gas pressure valve

3.3 DIMENSIONS OF DIGESTER

Mesophilic tank

$$\begin{aligned}
 1) V_R &= \pi r^2 h \\
 &= \pi [(31.2 \times 10^{-2})/2]^2 \times 0.90 \\
 &= 0.0688 \text{m}^3 \\
 &= 0.0688 \times 10^3 \\
 &= 68.8 \text{ Liters}
 \end{aligned}$$

$$2) \text{HRT} = V_r / V$$

$$35 = 68.8 / V$$

$$V = 1.96 \text{ liters}$$

$$3) B_r = mc / V_r$$

$$= (2 \times 0.75) / (68.8 \times 10^{-3})$$

$$= 21.80 \text{ Kg/d.m}^3$$

B_r = organic load (Kg/d m^3)

m = mass of substrate fed per day (Kg/d)

C = concentration of organic matter (%)

V_r = digester volume (m^3)

V = Volume of substrate fed per unit time (m^3/d)

HRT = Hydraulic Retention time.

Thermophilic tank

$$1) V_R = \pi r^2 h$$

$$= \pi [(36.2 \times 10^{-2})/2]^2 \times 0.34$$

$$= 0.03499 \text{ m}^3$$

$$= 0.03499 \times 10^3$$

$$= 34.99 \text{ Liters}$$

$$2) \text{HRT} = V_r / V$$

$$35 = 35 / V$$

$$V = 1 \text{ liters}$$

$$3) B_r = mc / V_r$$

$$= (2 \times 0.75) / (25 \times 10^{-3})$$

$$= 42.85 \text{ Kg/d m}^3$$

4. CONCLUSION

This biodigester can be a boon for domestic waste management and satisfy energy needs. As it functions in the absence of oxygen and the entire fermentation process occurs in sealed tanks, the odor is of no concern. Wet kitchen waste is degraded in these sealed tanks to produce biogas of about 0.4 cubic meters per day. Solar panels or electric heaters can be used to obtain the desired temperature depending upon the climatic conditions. Thus, it is an effective alternative way to not only produce a clean and economic form of energy but also to reduce waste. In the long run, there is immense need for modernization to overcome the drawbacks of the biodigester that have been used for years. Moreover, it would be more beneficial if awareness is spread among people to deal with waste judiciously.

REFERENCES

- [1] Salma A. Iqbal, Shahinur Rahaman, Mizanur Rahman, Abu Yousuf,” *Anaerobic digestion of kitchen waste to produce biogas*”,10th International Conference on Mechanical Engineering, ICME 2013.
- [2] Rajendra Beedu and Pratik Modi, “*Design of Bio Gas Generation Plant Based on Food Waste*”, International Journal of Current Engineering and Technology E-ISSN 2277 – 4106, P-ISSN 2347 – 5161.
- [3] A. Apte, V. Cheernam, M. Kamat, S. Kamat, P. Kashikar, and H. Jeswani, “*Potential of Using Kitchen Waste in a Biogas Plant*”, International Journal of Environmental Science and Development, Vol. 4, No. 4, August 2013.
- [4] Ravi P. Agrahari, G. N. Tiwari,” *The Production of Biogas Using Kitchen Waste*”, International Journal of Energy Science (IJES) Volume 3 Issue 6, December 2013
- [5] Sunil MP, Ashik Narayan, Vidyasagar Bhat, Vinay S,” *Smart Biogas Plant*”, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-3, Issue-3, August 2013.
- [6] www.arti-india.org/
- [7] Arti Pamnani and Meka Srinivasarao, Municipal Solid Waste Management in India: A Review and Some New Results, *International Journal of Civil Engineering and Technology*, 5(2), 2014, pp. 01–08.